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December 1953

United States Department of Agriculture
Agricultural Research Service
Bureau of Entomology and Plant Quarantine

EFFECT OF CHLORINATED ORGANIC COMPOUNDS ON PLANTS GROWN IN TREATED SOIL

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When tests indicate that a new chemical has value for control of larvae of the Japanese beetle (Popillia japonica Newm.), it is important to determine whether plants can be grown in the treated soil. It has been the practice at the Japanese beetle laboratory to obtain preliminary information on the reaction of plants by growing some of the common vegetables and flowers in the greenhouse in pots containing soil treated with insecticidal concentrations of the new chemical. The reaction of these plants to some of the chlorinated organic compounds in the soil is reported herein.

Experimental Procedure

All the chlorinated organic compounds tested were of the technical grade used in insecticides and were formulated as dusts of known concentration by the manufacturer.[2/] They were diluted further with talc to facilitate mixing them with soil.

The medium for growing the plants was composed of 3 parts of Sassafras sandy loam, 2 parts of sharp sand, and 1 part of sifted peat by volume, mixed intimately in a rotating drum. The acidity of the soil was adjusted to a pH of about 6.4 by the addition of hydrated lime, and then a commercial 5-10-10 fertilizer was added at the rate of 20.8 grams per cubic foot, which was equivalent to 500 pounds per 3-inch acre.

1/ The writers acknowledge the assistance of L. W. Coles, C. A. Perkins, and H. W. Strabel of the Japanese beetle laboratory in conducting this investigation.

2/ Aldrin, dieldrin, endrin, and isodrin were obtained from Julius Hyman and Company Division, Shell Chemical Corporation, heptachlor from the Velsicol Corporation, and lindane from the California Spray-Chemical Corporation.

Each chlorinated organic compound was intimately mixed with the prepared growing medium in a rotating drum. Aldrin and dieldrin were applied at rates equivalent to 1.5, 3.0, and 6.0 pounds per 2-inch acre. Endrin was applied at rates equivalent to 1, 2, and 4 pounds, heptachlor and lindane at rates equivalent to 2, 4, and 8 pounds, and isodrin at rates equivalent to 0.15, 0.3, and 0.6 pound per acre. In most cases the lowest dosage was one-half that required to kill third-instar larvae of the beetle. It was later found that at least 8 pounds of lindane per acre is needed for control of Japanese beetle grubs. This material should therefore have been used at greater dosages. The soil for each series of tests was placed in clay pots of suitable size and set on the greenhouse bench.

Some seeds, including bean, beet, carrot, corn, morning-glory, radish, squash, sweetpea, and turnip, were sown directly in the pots, 2 or 3 seeds per pot, and after the plants were well established they were thinned to 1 per pot. Other plants, including aster, broccoli, cabbage, calendula, celery, eggplant, kale, lettuce, pepper, spinach, and tomato, were started in flats of untreated soil and were transplanted to pots of treated soil when the seedlings had developed their second leaves. After growing for several weeks the plants were harvested. The root crops were pulled, brushed clean of soil, and weighed individually, the other plants were cut at the surface of the soil and weighed in the same manner.

An effort was made to reduce to a minimum all variations in growth induced by factors other than the toxicant. Under ordinary greenhouse management uniform watering of the plants is a problem. In these tests the problem was solved largely by subirrigation. The benches were made watertight by caulking. Each bench was provided with a reservoir and an inverted V-shaped trough down the center so that water flowed freely, and then filled to a depth of 5 inches with clean sharp sand. Twice each week the benches were flooded with water to a depth of 1 inch to maintain the soil in good condition, and once each week the foliage was syringed lightly to remove dust from the leaves. In addition to maintaining adequate moisture in the pots, the layer of moist sand beneath the pots tended to equalize the temperature of the soil throughout the experimental units.

After the plants had been growing for 3 or 4 weeks it was evident that additional nutrients were required. Therefore, the surface of the soil was sprinkled lightly at weekly intervals with a 15-25-15 water-soluble commercial fertilizer mixed with water at the rate of 6 pounds to 100 gallons.

The control of damping-off fungi has been a serious problem in the growing of seedling plants in the greenhouse during the winter and early

spring. For this purpose a fungicide that would remain in the soil for only a short time was desired. In view of the results obtained by Doran, Guba, and Gilgut (1), the soil was sprinkled with 37-percent formaldehyde, diluted 1:1,000, immediately after the seed had been sown and two or three times subsequently at weekly intervals. Each application gave good protection for about 1 week but little or no protection after 2 weeks. No phytotoxic action was observed following this treatment; in fact, no harm seemed to be done to the foliage of small plants wetted by the solution.

Experimental Design

Although the soil in these tests was much more nearly uniform than would be encountered in field plots, it was realized that slight differences in the environment might affect the growth of the plants. The pots were arranged on the greenhouse benches in randomized blocks, rows of 4 to 9 pots being used as plots or units. Each block contained 7 rows of pots, 1 row for untreated soil, and the other rows for 3 concentrations each of 2 insecticides. Usually 3-inch pots were arranged 9 in a row and the blocks were replicated 3 times; 4-inch pots were placed 7 in a row and the blocks were replicated 4 times; 5-inch pots were placed 4 in a row and the blocks were replicated 6 times.

Analyses of the Data

Over 90 analyses were made of the variance in the total weights of the plants in the treatments in the replicated blocks. In most cases the differences in the green weights in the replicated blocks were not significant. The pooled standard deviation obtained in the analyses of variance was used in calculating in the usual manner the least significant difference between the green weights in the different treatments.

The results were expressed as relative values by dividing the mean weight of the plants in each treatment plus the weight required for significance by the mean weight of the plants in untreated soil and multiplying by 100. Since the relationship between the treatments and the difference required for significance had been determined with the original data, this method of expressing the results did not change the relationship between them.

In practically all the blocks a change of 20 percent in the green weight of the plants in treated soil as compared with the weight in untreated soil was found to be significant. A variation to this extent was therefore considered to be significant when the effect of the different chlorinated organic compounds on the various plants was evaluated.

Results

The effects on the growth of the plants in soil treated with various dosages of insecticides are shown in tables 1 to 3.

In soil treated with aldrin, hollyhock was somewhat retarded by all dosages, and beets, corn, radishes, verbena, and zinnia (Spun Gold) by the 6-pound dosage. With dieldrin, spinach and tomatoes (Marglobe) were retarded by the 3- and 6-pound treatments, and carrots, dianthus, hollyhock, radishes, and verbena by the highest dosage. With endrin, cucumbers, dianthus, and scabiosa were retarded by 2 and 4 pounds per acre, and centaurea, eggplant, and tomatoes (Marglobe) by 4 pounds. With isodrin, only scabiosa was significantly retarded by the highest dosage used. With heptachlor, corn, soybeans, and tomatoes were significantly retarded by the highest dosage. With lindane, corn was retarded by all dosages, eggplant by 4 and 8 pounds per acre, and soybeans, peppers, and tomatoes (Garden State) by 8 pounds.

When these insecticides were used at rates required to kill third-instar Japanese beetle grubs, all the plants grew normally in the soils treated with isodrin and heptachlor, 97 percent in soil treated with aldrin, 95 percent with dieldrin, 90 percent with endrin, and 79 percent with lindane. When the dosage was increased, additional plants were retarded in growth.

Conclusions

These tests indicate that certain sensitive crops may be injured by the chlorinated organic compounds when used at the dosages required to kill third-instar larvae of the Japanese beetle in the soil. Hollyhock appears very sensitive to aldrin, spinach and tomatoes to dieldrin, cucumbers, dianthus, and scabiosa to endrin, and soybeans, corn, eggplant, peppers, and tomatoes to lindane. However, with the possible exception of lindane, these insecticides might be used at the recommended rates without causing serious damage to most of the crops tested.

Literature Cited

Brown, W. L., Gaba, E. F., and Guyot, C. J.
1942. The control of damping-off of vegetables by formaldehyde and other chemicals. Mass. Agr. Expt. Sta. Bul. No. 394, 36 pp.

Table 1.--Effect of treatment of soil with aldrin and dieldrin on growth of garden plants

Plant	Number of plants per treatment	Weeks grown	Ratio of weight of plants in treated soil to weight in untreated soil (percent)[1/]					
			Aldrin, pounds per acre			Dieldrin, pounds per acre		
			1.5	3	6	1.5	3	6
Aster, Crego Crimson	27	13	93	94	93	92	95	86
Bean, Lima, Fordhook	28	4	92	91	87	97	99	95
King of Garden	25	4	98	98	83	98	97	92
Soy, Black Wilson	28	6	105	94	95	101	98	95
String, Black Valentine	28	5	98	99	86	95	89	90
Beets, Detroit Dark Red	27	9	95	83	74	98	91	91
Broccoli, Calabrese	27	8	100	101	109	107	98	104
Cabbage, Danish Roundhead	27	8	98	97	94	99	99	98
Chieftain Savoy	28	8	112	123	124	122	109	99
Perfection Savoy	27	8	99	94	96	100	95	91
Calendula	27	10	107	99	105	99	100	102
Carrots, Danver's Half-long	27	10	100	102	101	100	99	80
Celery, Fordhook	27	12	107	95	93	97	100	87
Centaurea, Snowman	27	9	95	96	104	102	95	93
Chihli	27	6	100	98	103	103	102	104
Chrysanthemum, Eastern Star	27	10	92	95	83	91	90	90
Corn, Golden Bantam	28	6	102	87	76	103	97	83
Cucumber, A. & C.	28	8	102	106	99	100	94	93
Dianthus, Snowball	27	11	98	89	85	110	100	79
Eggplant, Black Beauty	27	14	98	97	97	97	100	97
Hollyhock, Indian Spring	27	12	78	76	70	92	82	63
Kale, Blue-Curled Scotch	27	9	93	97	105	102	104	98
Lettuce, Black Simpson	28, 27[2/]	9	96	97	99	100	99	94
Morning-glory, Heavenly Blue	27	5	98	91	92	101	96	107
Peppers, N.J. Worldbeater	27	13	109	105	106	114	114	106
Poppy, Oriental	27	11	107	101	99	106	100	106
Radishes, Scarlet Globe	27	6	82	83	80	83	81	80
Spinach, Bloomdale	18	12	86	85	82	83	80	70
Squash, Cocozelle	28	5	100	110	99	100	98	101
Sweetpea, Pinkie	28	10	101	97	89	98	98	90
Tomatoes, Garden State	27	8	97	96	82	91	90	86
Marglobe	27	8	96	88	91	88	76	72
Rutgers	28	8	98	103	95	99	101	91
Turnips, Purple-top White Globe	27	7	105	102	98	96	98	89
Verbena, Venus	16	9	80	81	76	94	94	68
Zinnia, Pink Beauty	20	10	135	93	110	92	108	98
Spun Gold	20	7	90	85	75	96	106	87
Average			98	95	93	99	97	91

1/ Least significant difference 20 percent.

2/ The first figure refers to the aldrin and the second to the dieldrin.

Table 1.—Effect of treatment of soil with endrin and isodrin on growth of garden plants

Plant	Number of plants per treatment	Weeks grown	Ratio of weight of plants in treated soil to weight in untreated soil (percent)[1]					
			Endrin, pounds per acre			Isodrin, pounds per acre		
			1	2	4	0.15	0.30	0.60
Aster, Crego Crimson	27	10	91	93	82	104	97	93
Bean, Lima, Fordhook	20	4	89	88	88	93	97	81
Soy, Black Wilson	27	5	104	93	86	106	96	95
String, Black Valentine	28	5	109	99	90	98	102	94
Beets, Detroit Dark Red	28	11	100	95	81	107	102	107
Broccoli, Calabrese	27	7	101	108	86	102	108	105
Cabbage, Savoy	20	8	98	104	91	95	98	105
Calendula, Orange Sunshine	16	12	-	-	-	98	96	95
Carrots, Danver's Half-long	27	10	96	92	84	99	100	99
Celery, Fordhook	27	10	115	101	91	99	101	101
Centaurea, Snowman	21	8	99	85	80	100	100	100
Chrysanthemum, Eastern Star	24	12	-	-	-	99	95	88
Evening Star	27	9	90	89	81	102	96	104
Chard	27	6	96	96	86	98	105	97
Corn, Golden Bantam	28	6	99	101	87	100	99	91
Cucumber, A. & C.	32	8	95	78	74	107	97	93
Dianthus, Chinensis	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	96
Eggplant, Black Beauty	27	11	93	88	77	93	93	91
Hollyhock, Indian Spring	24	8	-	-	-	104	101	104
Kale, Blue-Curled Scotch	27	7	[illegible]	90	85	96	94	92
Lettuce, Black Simpson	27	8	104	105	95	105	112	107
Morning-glory, Scarlet O'Hara	27	7	90	89	82	99	111	99
Peppers, N. J. Worldbeater	27	11	98	101	83	102	103	88
Poppy, Oriental	27	14	100	110	98	111	107	109
Radishes, Scarlet Globe	27	5	98	90	87	96	94	93
Scabiosa, Blue Cockade	27	6	87	80	68	96	88	77
Squash, Cocozelle	28	6	91	93	84	100	109	113
Sweetpea, Pinkie	28	7	100	93	82	105	95	102
Tomatoes, Garden State	27	11	110	97	92	98	95	97
Marglobe	27	11	87	87	77	100	98	93
Rutgers	27	11	90	93	87	99	98	100
Turnips, Purple-top White Globe	27	6	155	97	98	100	97	96
Verbena, Venus	27	10	122	100	97	106	91	93
Zinnia, Spun Gold	20	7	90	84	84	127	106	106
Average			90	94	85	101	100	97

1/ Least significant difference 20 percent.

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Table 3.--Effect of treatment of soil with heptachlor and lindane on growth of garden plants

Plant	Number of plants per treatment	Weeks grown	Ratio of weight of plants in treated soil to weight in untreated soil (percent)[1]					
			Heptachlor, pounds per acre			Lindane, pounds per acre		
			2	4	8	2	4	8
Bean, Lima, King of Garden	25	4	107	116	107	105	110	116
Soy, Lincoln	25	7	102	90	75	81	79	78
Beets, Detroit Dark Red	[2] 25, 28	[2] 14, 11	103	103	85	103	101	98
Broccoli, Calabrese	27	5	98	89	91	103	93	87
Cabbage, Chieftain Savoy	27	5	105	101	97	101	106	109
Carrots, Danver's Half-long	25	13	103	98	90	99	103	102
Corn, Stowell's Evergreen	25	5	95	83	56	80	80	73
Cucumber, A. & C.	25	10	101	100	88	88	87	82
Eggplant, Black Beauty	25	14	101	89	82	88	79	78
Lettuce, Black Simpson	28	8	98	106	87	107	94	104
Peppers, N. J. Worldbeater	25	12	96	92	93	87	84	80
Radishes, Early Scarlet Globe	25	7	106	105	93	100	97	98
Spinach, Woodruff's	25	12	109	112	108	97	91	87
Squash, Cocozelle	25	4	97	98	90	106	99	105
Tomatoes, Garden State	28	10	92	92	73	90	84	71
Marglobe	28	10	91	96	87	94	97	89
Rutgers	28	10	92	92	87	99	97	90
Turnips, Purple-top White Globe	28	11	96	95	111	109	116	119
Watermelon, Dixie Queen	28	9	99	100	80	99	98	101
Grasses, Redtop[3]	--	9	95	104	94	106	100	101
Kentucky Blue	--	9	108	100	91	93	87	84
Colonial Bent	--	9	95	99	87	89	88	88
Clover, White Dutch	--	9	95	100	90	107	105	100
Average			99	98	89	97	95	93

[1] Least significant difference 20 percent.

[2] The first figure refers to the lindane and the second to the heptachlor.

[3] Twenty-four 5-inch pots were used for each treatment.

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